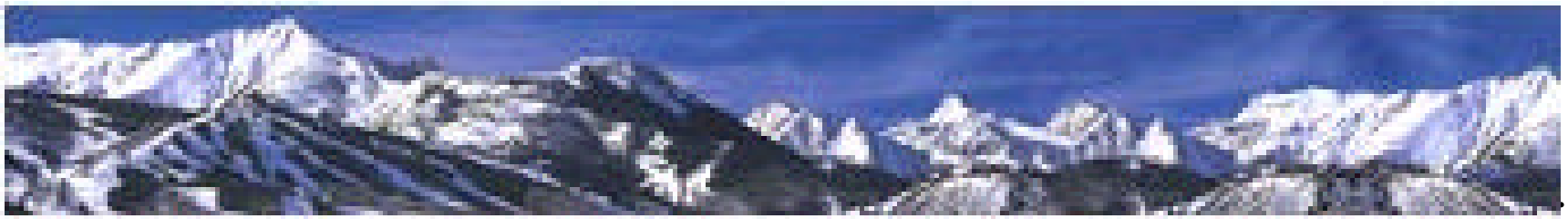
R & D Issues for
High Intensity Proton Sources

M6 Working Group

Snowmass, July 20, 2001



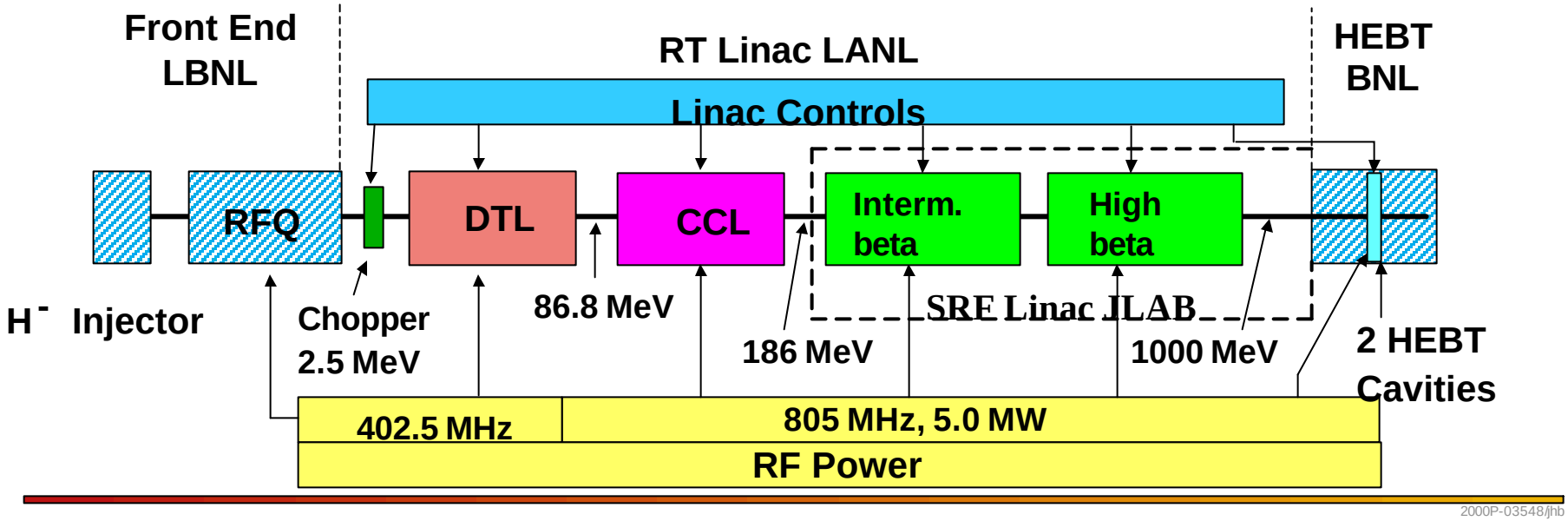
Present status

- **Proposed PD projects: technically feasible? cost effective?**

- Present construction projects serve as best R&D and prototypes for high intensity proton sources
  - Spallation Neutron Source: up to 2 MW
    developed super-conducting RF linac for intense proton beams
  - JAERI/KEK: 1 MW multi-purpose
    Rapid-cycling synchrotrons for intense beams
- No show stoppers towards a multi-MW source, based on present accelerator technology
- Reliable cost estimates based on line-item construction projects

Example: SNS technology (transfer?)

- SNS technologies for direct adoption
  - (engineering) Superconducting RF cavity, couplers, RF control
  - (simulation) Codes development including space charge, impedance, painting, collimation, fringe fields, (electron-cloud)
  - (experiment) Collimation study at Protvino, space charge comparison with PSR



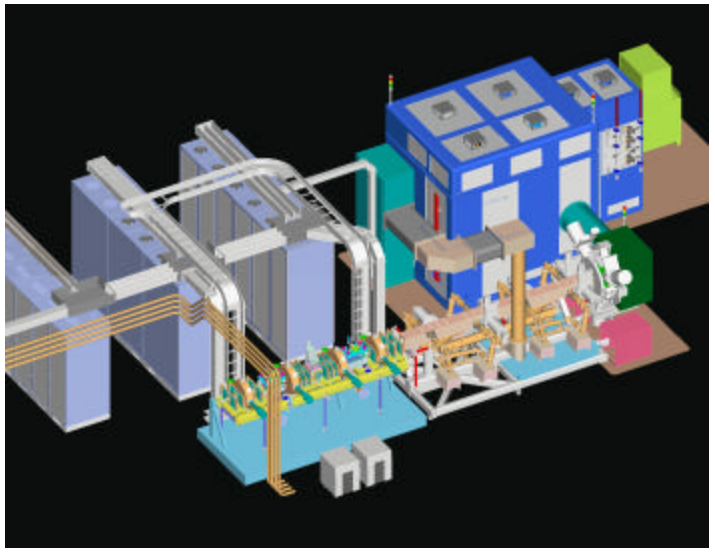
M6 Group R&D items

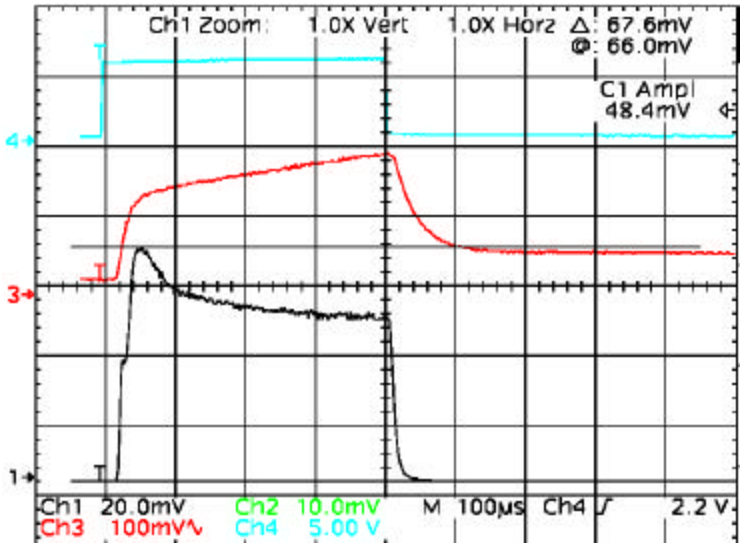
- Engineering
  - Ion source lifetime
  - Superconducting RF linac gradient, RF control
  - Ring RF gradient, magnet, coil, modulators, kicker impedance, collimation
  - New development: FFAG, Inductive insert, induction synchrotron
- Simulation
  - Codes development & benchmarking
  - Electron cloud effects
- Experiments
  - Halo experiments
  - Diagnostics

H^- ion source; lifetime

- Goal
  - 60-70 mA current; 6-12% duty
  - 0.2πmm mr rms norm. emittance
  - 60 day lifetime
- Achieved
  - 35-50 mA current; 6% duty
  - Up to 20 day lifetime
- Main focus on ion source lifetime and machine availability
  - Antenna coating
  - Cesium enhancement & sparking
  - Electron dumping

(Courtesy LBNL / R. Keller)

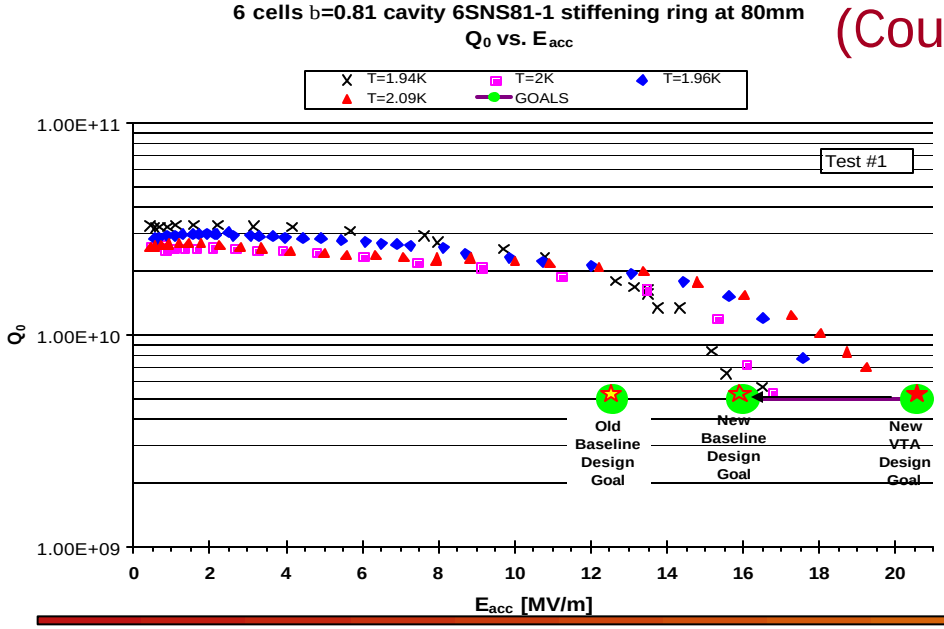


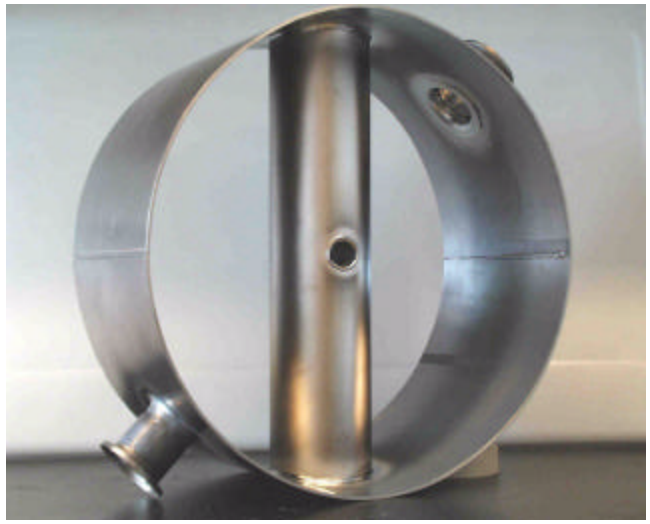


Superconducting RF linac cavities

- Steady increase in accelerating gradient
  - Achieved (E_{acc}) 16 MV / m; electro polishing, Nb sheet scan
  - Nb / Cu sputtered cavity at CERN; 4.5° operation
- Extending SC technology towards lower β (0.17-0.34)
  - Power saving, larger aperture for lower loss

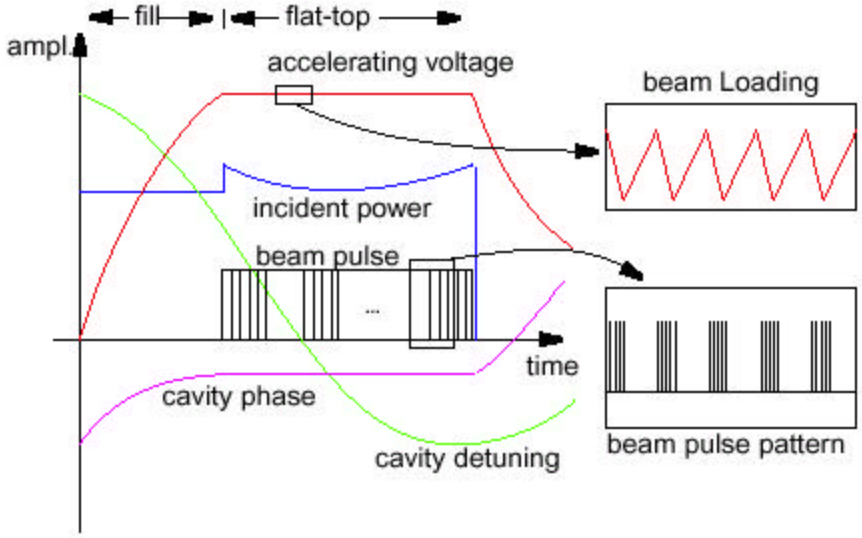
(Courtesy Jlab/C. Rode, ANL, T. Wangler)

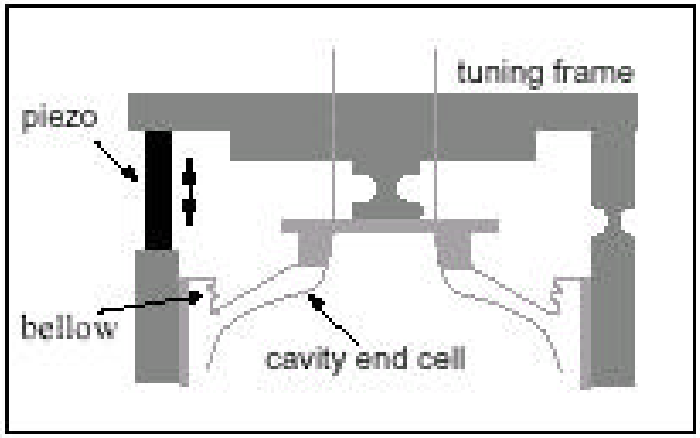


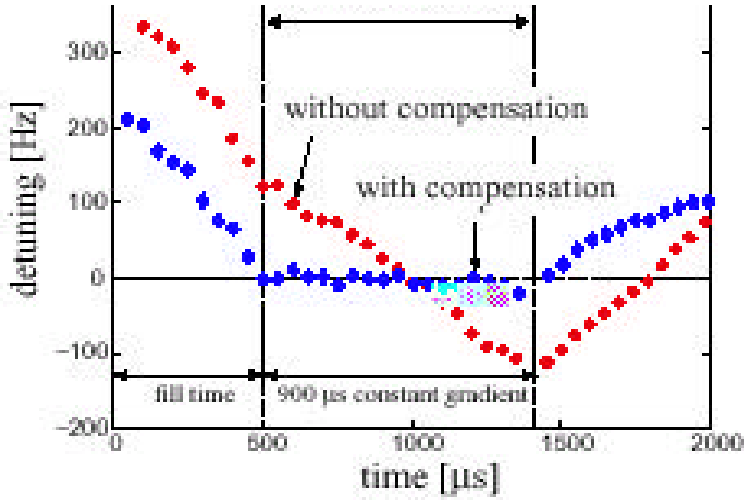


Linac RF control for pulsed operation

- New challenges from pulsed superconducting RF linac
  - Lorentz detuning, ~E_{acc}^2
  - Microphonics
- Development of piezo-translator for measurement/feedforward compensation (RF power saving)
  (Courtesy M. Liepe, S. Simrock)

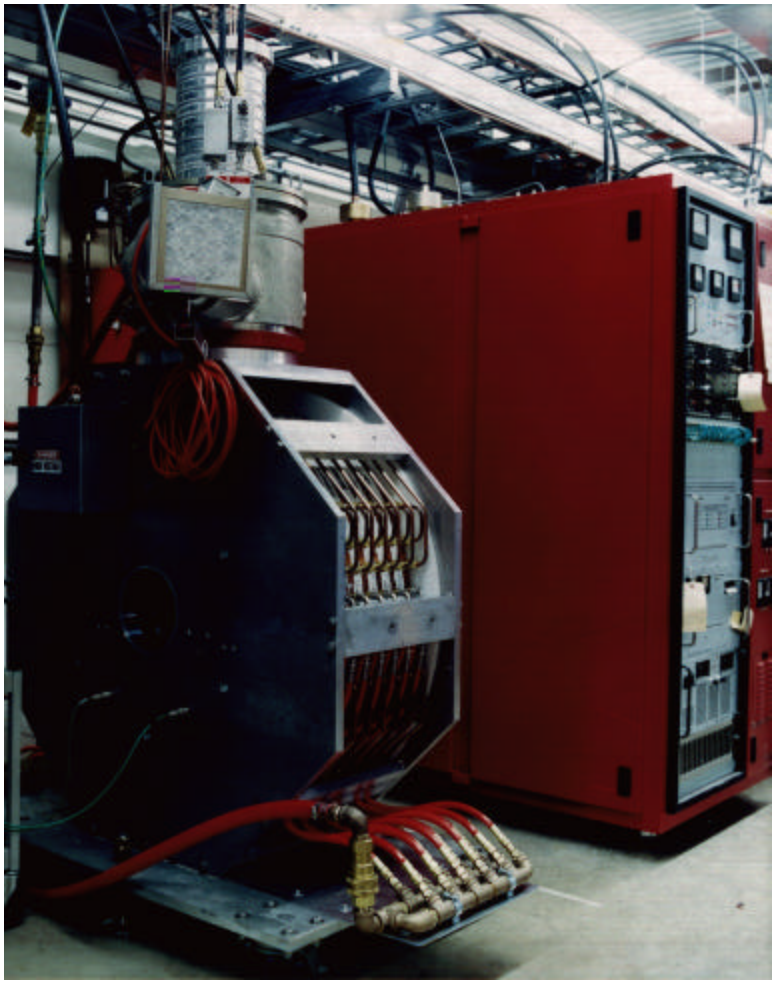






Ring RF development

- Development of Magnetic Alloy (MA) loaded cavity of high gradient
  - Goal: 50-100 kV / m at low frequency (few MHz) with 50-60% duty cycle (conventional ferrite loaded: 10 kV / m)
  - Need to investigate power load / cooling, beam loading
- Development of burst mode RF of high gradient (~1 MV / m) at low frequency (~5 MHz)

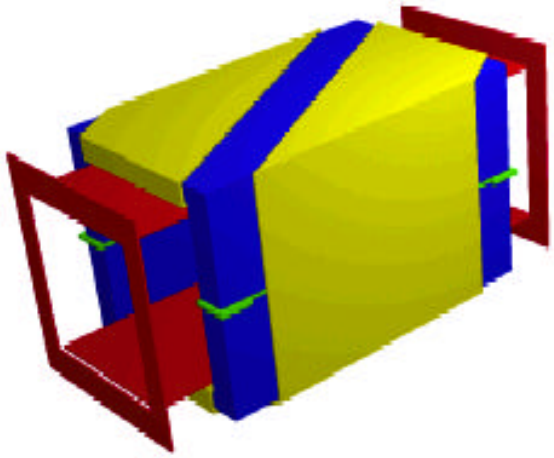


(Courtesy Y. Mori)

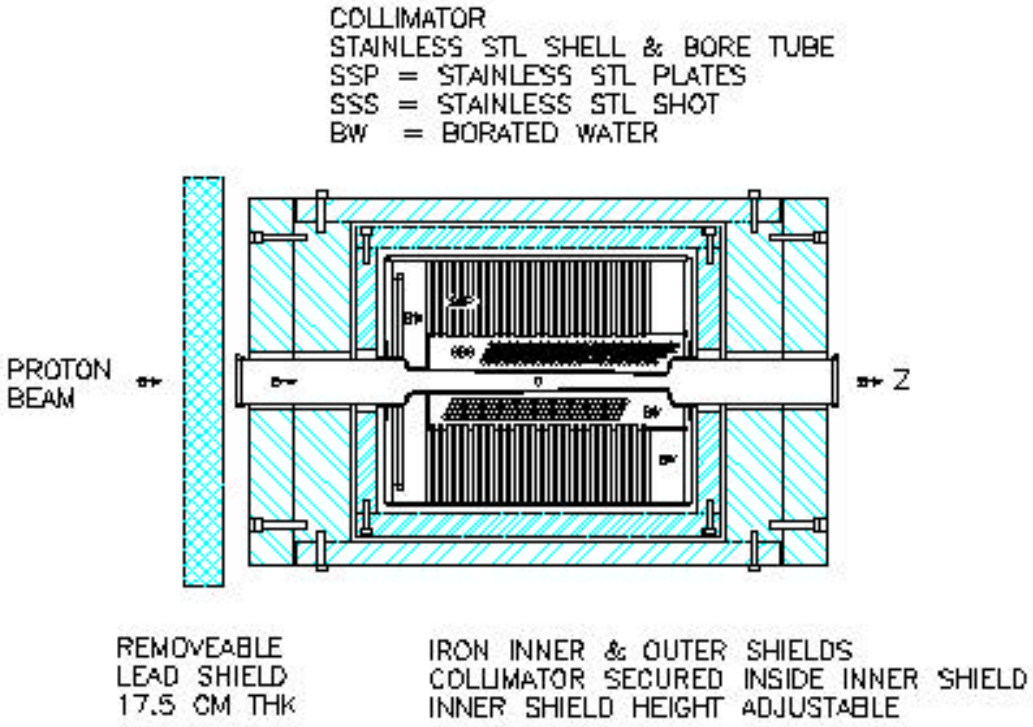
Extraction kicker & modulator

- Development of solid-state (stacked Mosfet) modulators
  - Fast rise / fall time (10-20 ns)
  - Possible reliability improvement
- Impedance reduction of lumped ferrite kickers

(Courtesy AHF/A. Thiessen, Y.Y. Lee)



Collimation and cleaning



SCHEMATIC OF COLLIMATOR COMPONENTS
HORIZONTAL SECTION

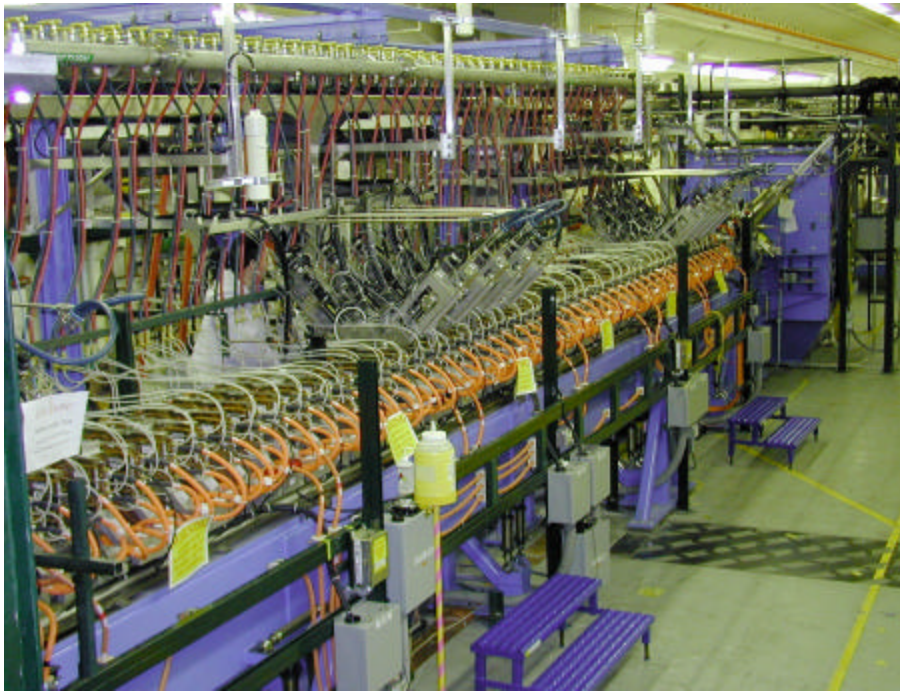
- Development of high-efficiency 2-stage collimation
- Development of self-shielding collimator
- Development of beam-in-gap cleaning

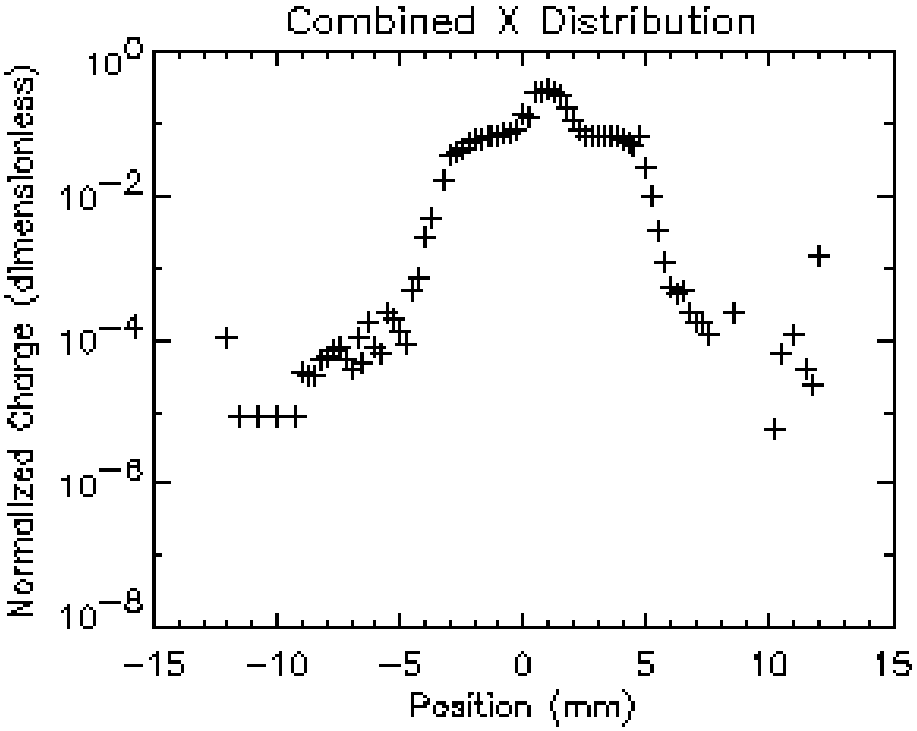
(Courtesy H. Ludewig)

Space charge and halo study

- LEDA halo experiment and unresolved issues
  - Higher-than-predicted emittance / halo growth; profile structure
- Parametric resonance, space charge coupling resonance

(Courtesy T. Wangler, P. Colestock)

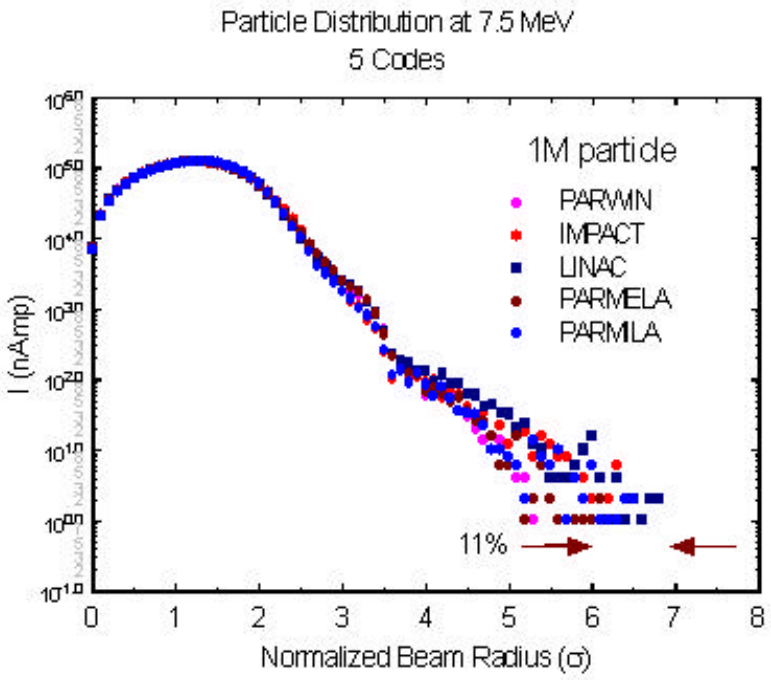


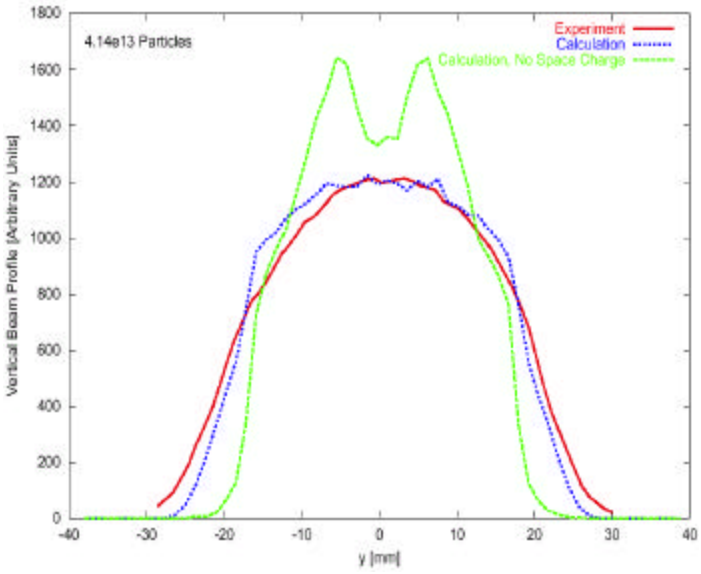


Machine study/codes benchmarking

- Machine study: halo experiments for both linac and ring; space charge effects; collimation; electron cloud
- Codes comparison: linac codes and ring codes

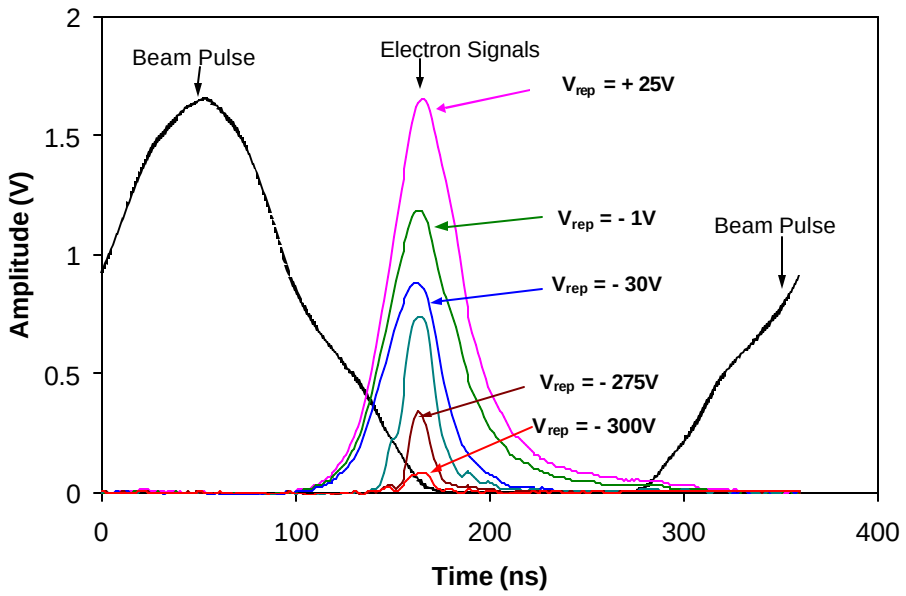
(Courtesy LANL/S. Nath, J. Holmes)





Electron cloud effects

- Intensity limiting mechanism at PSR and SPS
- Extensive effort is needed
  - Theory: to reliably predict instability threshold and growth rate for bunched beam
  - Measurement / simulation: on electron accumulation and secondary yield details
- Cures
  - Investigate surface treatment & conditioning
  - Development of wide-band, fast, active damping system at frequency 50-800 MHz

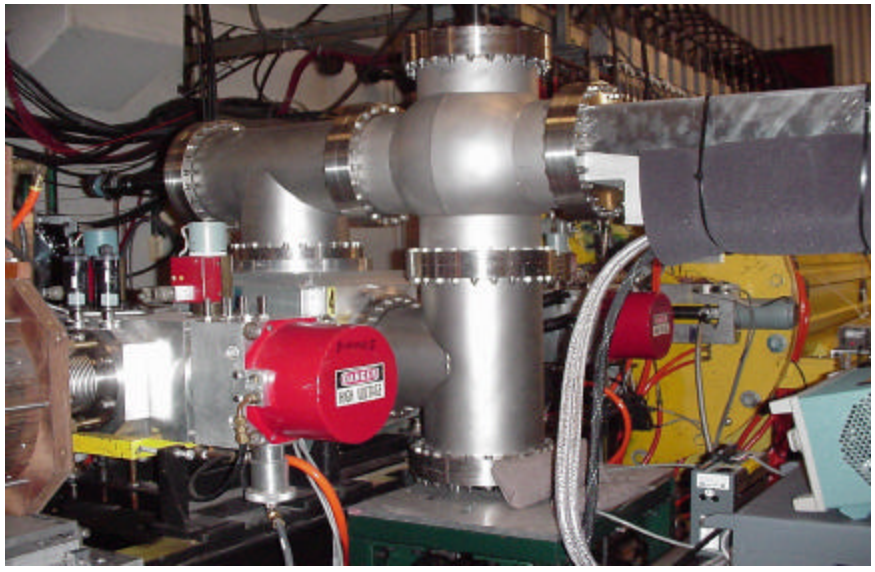


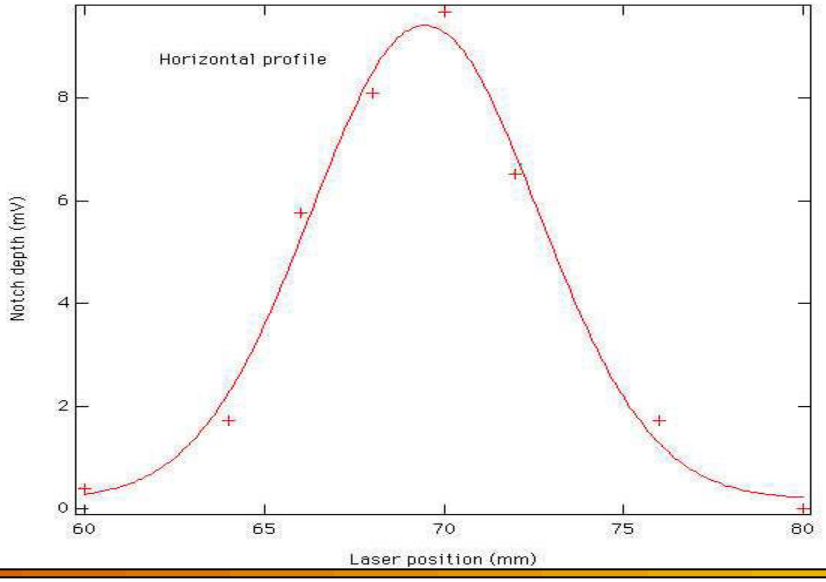
(Courtesy R. Macek)

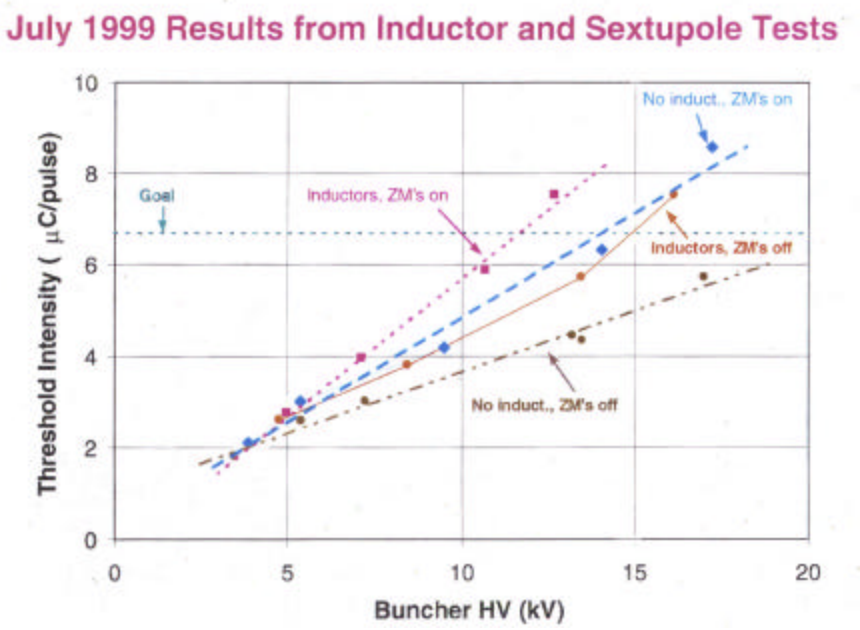
Diagnostics

- Whole area of diagnosing beam parameter during multi-turn injection; profile measurement over wide range, turn-by-turn
- Development of laser-based profile measurement for H^- beam
  - Avoid wire heating at low energy
  - Superconducting environment cleanness requirements

(Courtesy BNL/P. Cameron)







(Courtesy W. Chou, R. Macek)

Summary

- Presently proposed Proton Drivers (FNAL, BNL) are feasible and cost effective
- Based on current technology, there are no show stoppers
- Present construction projects serve as best R&D and prototypes for high intensity proton sources